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MCDA applied to performance analysis and evaluation of Road drivers: A Case Study in the Road Transport Company

Abstract

Performance evaluation increasingly assumes a more important role in any organizational environment. In the transport area, the drivers are the company's image and for this reason it is important to develop and increase their performance and commitment to the company goals. One way of doing so is through evaluation, which can be used to motivate drivers to improve their performance and to discover training needs.

This work aims to create a performance appraisal evaluation model of the drivers based on the multi-criteria decision aid methodology. The PROMETHEE and MMASSI methodologies were adapted by using a template supporting the evaluation according to the freight transportation company in study. The evaluation process involved all drivers (collaborators being evaluated), their supervisors and the company management.

The final output is a ranking of the drivers, based on their performance, for each one of the scenarios used. The scenarios have been constructed according to the organization needs. The results produce are to be used as a decision tool to allocate drivers to the national transportation service. In addition, the results obtained can be used to develop the driver's skills since it allows for the identification of specific and personal needs for improvement and development.

Keywords

Multi-criteria decision, Performance Appraisal, Road freight transport.

1. Introduction

Performance appraisal (PA) can be seen as a set of structured formal interactions between a subordinate and a supervisor. In this sense, de PA of each subordinate is based on a set of relevant criteria, which are designed in order to identify weaknesses and strengths, as well as opportunities for performance improvement and skill development. Hence, setting up and implementing PA serves various purposes, such as: promotion, remuneration adjustment, personnel planning, training needs, among others (Grund et al., 2012 e Zheng et al., 2012).

Some organizations use PA evaluation activities to disseminate amongst the employees their organizational strategies, goals, and vision. This knowledge may lead the employees to have higher levels of commitment due to the additional clarity of the company goals, and thus their own, and to the additional perception of being valued and seen as part of the company team (Kuvaas, 2006). It is also important to note that for a performance assessment to be successful it needs to be and convey to all participants, values such as clarity, fairness, accuracy, reliability, validity, amongst others (Almeida, 1999).

In here, the performance evaluation is performed by using Multi-Criteria Decision Analysis methodology (MCDA), which purpose is to support decision makers to rank possible solutions. Typically, there does not exist an optimal solution for this type of problems since the criteria, some or

all, are conflicting. Thus, it is necessary to use decision maker's preferences to differentiate between solutions.

The main advantages of MCDA are mainly due to i) the possibility of incorporating quantitative and qualitative criteria, ii) the ability to deal with criteria which are difficult to quantify and be compared to each other, and iii) the proper balance between analytical methods and decision makers subjective evaluations.

Recent applications of MCDA to PA include Albayrak & Erensal (2004), Anisseh et al. (2007) and Manoharan et al. (2011).

This paper is organized in 5 sections. Section 1 introduces the problem context, while Section 2 explains the methodology and models used. The case study is presented in Section 3 and the main results obtained are discussed in Section 4. Finally, Section 5 draws some conclusions.

2. Methodology

MCDA is an approach to problems involving several criteria or objectives, which may have different scales, both monetary and non-monetary, and some might be to be maximized, while others might be to be minimized. For these problems, usually, there are several alternative solutions that are to be ordered, from the most preferred to the least preferred one, and none is the best since none is better in achieving all objectives. Thus, the objective is not to provide the Decision Maker (DM) with a solution, but rather to help the DM to understand the conflicts and trade-off needed amongst the objectives, e.g. options that are more beneficial are also usually more costly, and make his/her own judgments both regarding the objectives and the alternatives.

Steps involved in applying MCDA:

1. Establish the problem context and structure;
2. Identify the set of alternatives;
3. Identify objectives and criteria;
4. Find a score for each alternative regarding each criterion;
5. Find weights for each criteria;
6. Combine weights and scores to obtain an overall value for each alternative;
7. Analyse the results;
8. Perform sensitivity analysis.

Steps 3 to 6 are discussed in greater detail, since in the case study performed these steps involved group decision strategies due to the fact that several decision makers have been involved. It should be noticed that, the decision makers involved had different roles within the company and thus their judgments are not valued the same.

Regarding the identification of the alternatives not much had to be done since the management of the company decided that all drivers should be considered. The strategy followed to address the identification of criteria was to cluster them under higher-level and lower-level generic objectives in a hierarchy. Then, the objectives have been more detailed resorting to a value tree. The performance of each driver on each criterion has been achieved by using scales representing preferences for the consequences, in particular relative preference scales. The weights for each of the criterion have been obtained by considering all decision makers opinions. Each of which provided an opinion after being guided through a swing weighting procedure, i.e. comparing differences between highest and lowest scores for each of the criterion. An overall preference score is then usually obtained by computing a weighted average of the drivers' scores on all the criteria. However, since several DMs are considered this only allows obtaining each DM global preference for each driver. Thus, an additional step is required. In this new step an aggregation of the individual preferences has to be performed (Ishizaka et al., 2013). A more detailed description is provided in Section 3.

The last step provides confidence on the results achieved since it allows for performing sensitivity analysis to assess the robustness of the preference ranking to changes in the criteria scores and/or the assigned weights. Sensitivity analysis measures the impact of small perturbations in the variables of the problem (e.g. criteria scores and criteria weights) in terms of alternatives, by means of the comparison of the modified ranking with the original one. The closer the rankings, the more robust the method is. These steps are important to increase the DM's confidence in the outcome of the multi-criteria decision analysis.

There are several different methods to applied MCDA. In here we chose to use the Preference Ranking Organisation METHod of Enrichment Evaluation (PROMETHEE) family of methods (Brans and Mareschal, 2005; Bogdanovic et al, 2012) and the MMASSI (Pereira, 2003; Pereira and Fontes, 2012). A brief description of each follows.

2.1. PROMETHEE - Preference Ranking Organization Method for Enrichment Evaluation

The PROMETHEE is a widespread method used for addressing decision making problems (see for instance Behzadian et al. (2010) for a comprehensive review of its applications). The PROMETHEE belongs to the European school of thought, which embodies a set of methods relying on the concept of partial aggregation, as opposed to the complete aggregation previously proposed by the American school. Methods of partial aggregation are better known as outranking methods.

A preference index that expresses the intensity of preference of alternative a over alternative b, is used as the basis to compute "core" quantities, namely the outranking flows. A positive (or leaving) outranking flow measures the degree to which a given alternative outranks all the other alternatives. Likewise, the negative (or entering) outranking flow expresses how much a given alternative a is dominated (or outranked) by the other alternatives. The higher/smaller the positive/negative flow, the better the alternative. The balance between these flows is represented by the net outranking flow, which is a dimensionless quantity. A higher value of this net flow reflects a higher attractiveness of alternative a.

The GAIA plane is a geometrical representation of the relative position of the alternatives in terms of contributions to the various criteria. The GAIA directly results from applying the principal component analysis to the matrix of normed flows defined for alternative and criterion j. Hence, the n-dimensional criteria space is projected onto a two-dimensional space yielded by the two most representative principal components (linear combinations of the original criteria) so as to preserve as faithfully as possible the original multidimensional information. The GAIA plane has the particularity of projecting in the same space both the alternatives and the criteria. Furthermore, it makes it possible to project the criteria weights vector using the so-called decision axis. The decision axis, along with the walking weights, can be used to further perform a sensitivity analysis of the results according to the weight changes.

2.2. MMASSI - Metodologia Multicritério para Apoio à Seleção de Sistemas de Informação

MMASSI relies on existing normative methods, which were developed along the lines of the American school of thought. It can be distinguished from previously proposed MCDA methodologies in the sense that (a) it provides the DM with a pre-defined set of criteria that tries to generally cover all the relevant criteria in the field of application (b) it does not explicitly requires the presence of a facilitator, or analyst, to guide the DM throughout the decision process, since it is implemented in an user-friendly and self-explanatory software (c) it uses a continuous scale with two reference levels and thus no normalization of the valuations is required.

MMASSI uses a fixed continuous scale with seven semantic levels with two references, so as to set up the ground values based on which the DM assesses each considered alternative against each selected criterion. The construction of this scale was based on earlier work by Bana e Costa and Vansnick (1999). Having defined the criteria, the possible courses of action and a continuous semantic scale, in the next phase the DM appraises each alternative by allotting a semantic level to each criterion. The last step of MMASSI involves the computation of an overall score for each alternative, according to an additive aggregation model, and the subsequent ranking of the alternatives.

3. Case Study

The case study company is a Portuguese road transportation major national logistics operator. This company offers transportation services, both domestic and international, general cargo, express courier, intermodal and container, as well as all the logistics, warehousing and distribution work.

In this type of company, the drivers turn out to be the company's main contact with the customer, and thus the company's image. Therefore, drivers' performance assessment may be a crucial element for improving organizational performance and assist in achieving company goals.

Having better knowledge of drivers, their ability and commitment to the company can be used to improve the allocation of drivers to specific routes. In addition, the company can make better regarding drivers' training and development. These may, in turn, lead to drivers increased motivation and willingness to adapt their own efforts to improve their performance and simultaneously carry out their work more efficiently.

The main objective of this case study is to evaluate the performance of the drivers performing domestic transportation. The evaluation period considered consists of the 15 months comprising January 2012 to March 2013. The methodologies used to perform the aforementioned evaluation have been the PROMETHEE and the MMASSI. The AHP has been discarded due to the excessive comparisons required, 5115 comparisons per DM.

3.1. Criteria

To define the criteria several meetings took place with the traffic director, the traffic managers, the route planner and the cost managers. Some meetings involved several of the above mentioned people, while others involved just one or two. From these meetings soon become apparent that there exist two major areas of interest: the technical characteristics of drivers, which are directly linked to their knowledge, driving performance, and service quality, and social characteristics, related their communication skills, their commitment to the organization, and availability (to take additional work loads, sacrifice off duty hours, etc.). It follows the schematic representation of the characteristics involved.

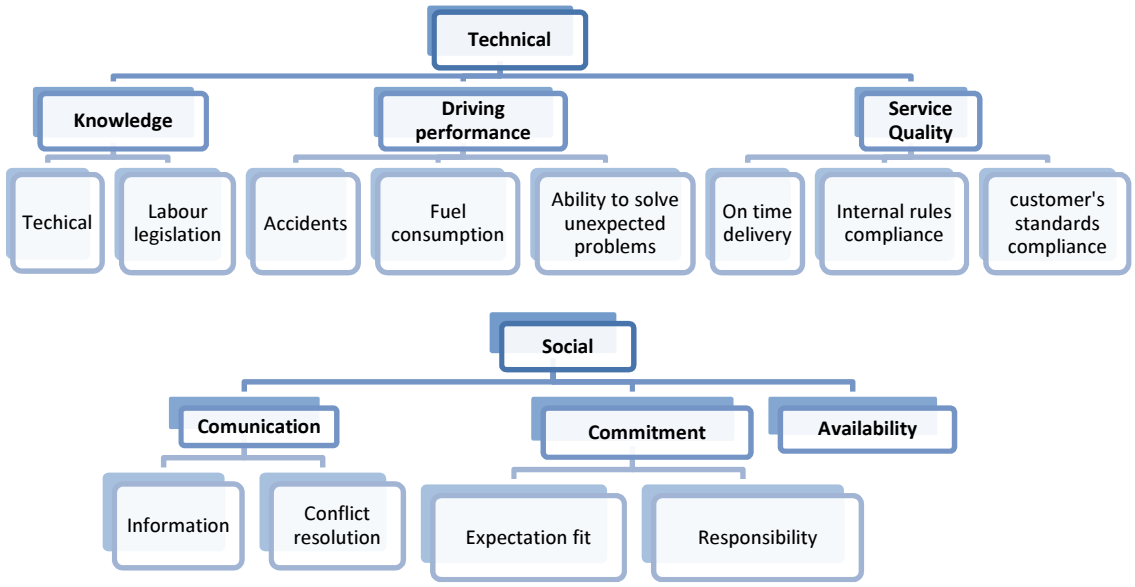

Figure 1. . Performance appraisal criteria.

It should be highlighted that there are only two quantitative criteria (number of accidents and fuel costs), the remaining being qualitative and thus subject to evaluation by the decision makers.

	PROMETHEE	MMASSI
Technical knowledge	7,64%	94
Labour legislation knowledge	7,73%	96
Accidents	7,98%	99
Fuel Consumption	7,70%	95
Ability to solve unexpected problems	7,42%	92
Delivery on time	7,97%	99
Internal rules compliance	7,56%	94
Customer's standards compliance	7,73%	96
Information	7,99%	99
Conflict resolution	7,79%	96
Expectation fit	7,38%	91
Responsibility	8,07%	100
Availability	7,05%	87

Table 1. Criteria weights.

In the case study, there are 15 decision makers deciding on the criteria to be used, as well as on the weight of each criterion. The decision makers opinion are not all valued the same: 12 of them have an individual weight of approximately 5.56% in the final score, while the remaining three have an individual weigh of approximately 11.11%. To obtain a global weight for each criterion a weighted average using individual DMs weights (see Table 1) and the weight of their opinion has been computed.

3.2. Drivers information gathering

Drivers performance on each of the 11 defined criteria is assessed by three DMs, each of which performing an individual evaluation for each driver. These DMs are considered as equal.

It should be highlighted that two different evaluation processes can be identified. On the one hand, the first two DMs make use of the full scale using it all to distinguish the performances of the evaluated drivers. On the other hand the third DM only uses a small range of the scale and thus no meaningful differences can be observed from the evaluations performed. Furthermore, when evaluations distinguish drivers, it is only done positively. In addition, this DM only evaluates a small number of drivers. Thus, drivers evaluated by this DM are in advantage since the DM evaluation improves their overall performance.

This led to the existence of two distinct analyses: one involving the three DMs and another involving only the first two. In addition, drivers perform self-assessment through a questionnaire. In Table 2, the ranking obtained through the analysis with two and three DMs, for both methods, are provided, as well as the one obtained by using the self-assessment information.

Rank	3 decision makers (MMASSI)		2 decision makers (MMASSI)		3 decision makers (PROMETHEE)		2 decision makers (PROMETHEE)		Self-assessment (PROMETHEE)	
1	**85**	56,70	**85**	50,48	**85**	0,402	**85**	0,476	**155**	0,515
2	**564**	47,40	**123**	41,49	**564**	0,320	**123**	0,460	**123**	0,367
3	**225**	44,92	**49**	40,77	**123**	0,307	**32**	0,446	**7**	0,346
4	**136**	44,23	**32**	40,41	**32**	0,298	**49**	0,440	**53**	0,336
5	**123**	41,49	**564**	39,22	**49**	0,293	**253**	0,388	**49**	0,282
(...)	**(...)**	**(...)**	**(...)**	**(...)**	**(...)**	**(...)**	**(...)**	**(...)**	**(...)**	**(...)**
27	**671**	5,18	**447**	-1,00	**192**	-0,243	**631**	-0,359	**68**	-0,355
28	**6**	1,20	**192**	-1,22	**68**	-0,301	**68**	-0,411	**206**	-0,439
29	**447**	-1,00	**631**	-3,60	**127**	-0,333	**155**	-0,460	**204**	-0,442
30	**631**	-3,60	**127**	-10,55	**155**	-0,344	**206**	-0,500	**127**	-0,509
31	**127**	-10,55	**206**	-10,88	**206**	-0,381	**127**	-0,500	**6**	n.a.

Table 2. Drivers ranking considering 2 or 3 decision makers and self-assessment.

4. Results and discussion

As I can be seen from the results reported in Table 2, driver number 85 is the one performing better on all scenarios considered. Actually, this is the only conclusion, i.e. ranking, on which all scenarios agree. It should be noticed however, that regarding self-assessment this drivers judged himself harshly since it is below the top 50% (actually in position 17). On the other end, drivers 127 and 206 are reported consistently as having the worst performances, even in their own opinion.

Another interesting observation is the fact that driver 155 considers himself very good: very good expertise and driving skills, as well as ability to communicate with the traffic manager, excellent at complying with internal and customer standards, with all deliveries on time, and total availability for any additional deliveries. However, the scores given by traffic managers show a different story. The global performance of this driver is at most neutral/slightly underperforming. Possibly these facts denote a lack of communication between the organization and the driver, or possible misunderstandings on what the company expects from the driver.

Despite the non-comparability of the resultant rankings, top preforming drivers are identified as such in all scenarios. The company may study in detail the information provided by these evaluations and thus be able to devise additional measure to be taken in order to improve drivers' motivation and thus performance.

5. Conclusions

MCDA is a problem solving methodology that organizes and synthesizes the information regarding a given decision problem in a way that provides the decision maker with a coherent overall view of the problem. MCDA methods assisted the company in the process of sorting the drivers using a set of complex objective an subjective, and conflicting objectives. The objectives have been measured by several DMs.

To operationalize the ranking of the 31 drivers involved two alternative MCDA methods have been used: PROMETHEE and MMASSI. The AHP has been discarded since it requires pairwise comparisons, which in this case and due to the large number of drivers and criteria would be too much time consuming.

Although sensitivity analysis is a very important step that can be used to examine how the ranking of options might change under different scoring or weighting systems and also in helping to resolve disagreements amongst DMs. In this case, the results obtained have shown to be insensitive to scores and weights variations.

Finally, it is important that performance appraisal is repeated periodically to monitor its benefits. In addition, the feedback given to the drivers can be most valuable and lead no only to improving the company performance but also to improvement drivers personal skills and commitment to the company.

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